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Differential Effects of Seedbed Density on Seedling Growth

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by

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Introduction

Although production methods in Ontario's forest tree nurseries are becoming highly mechanized, basic growth information is still required to understand how various cultural practices affect the growth and development of the seedling crops. It is also important to relate morphological changes to the physiological changes which could result and the effect they may have on initial survival and growth after planting. Use of nursery stock with vigorous growth characteristics induced by cultural practices would certainly assist in alleviating some reforestation problems particularly on very productive areas, such as mixedwood forest sites.

Unfortunately, some cultural techniques are not as easily applied as others. Seedbed density is one, however, that is a practical and controllable element in nursery soil management (Shipman 1964). Presented here are selected results from a nursery experiment in which the growth of two densities of rising 2+0 white spruce (*Picea glauca* (Moench) Voss.) was assessed in relation to regimes of soil moisture and nitrogen fertilization (McClain and Armson 1976).

The Experiment

Details of the experimental field layout are described elsewhere (McClain and Armson 1976). In essence, white spruce seedlings entering their second growing season at the Ministry's Orono Nursery were subjected to a thrice replicated split-plot experimental design in which four levels of N supply (0, 72, 144, 288 kg/ha) were nested within each of the three moisture regimes (A - moist, B - medium moist, C - natural precipitation). Moisture regimes A and B were maintained by irrigation from May to October 1972. All moisture and fertility combinations were laid out in seedbeds supporting two commonly used seedbed densities, 215 and 430/m^2. Prior to autumn ground frost, treatment effects were assessed by randomly selecting 30 seedlings across a transect in each treatment combination and replication and measuring all seedlings for total height, root collar diameter, and root area index (Morrison and Armson 1968). Seedling tops and roots from each treatment were separately weighed after drying at 80°C for 48 hou in a forced draught oven.

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Results

Differential Response. The effect of density can be seen by expressing the increase in seedling growth at the low seedbed density for each treatment combination as a percent of that at the high density (Table 1). The apparent effect of low seedbed densities was to accelerate growth rates This leads to larger stock. Rates of growth, however, were modified by moisture supply and N fertilization as can be noted by observing row and column means for moisture and N supply respectively.

Seedling dry weight, for example, responded dramatically at low seedbed density at moisture regime A (111.5% increase, fertility levels averaged) and less dramatically at moisture regimes B and C. Regardless of moisture supply marked increases in dry weight due to N supply occurred up until 144 kg/ha, then decreased. Similar trends for the other growth parameters can also be noted; some inconsistencies are evident however. Interestingly, all growth parameters were not similarly improved by a reduction in seedbed density; dry weight showed a substantial increase (84.5%) followed respectively by root area index (61.3%), root collar diameter (43.7%), and height (22.4%).

Stem Length. Total stem length is not often used as an expression of seedling development. However, as the size and spacing of needles (indicative of photosynthetic capacity) can be thought to relate to stem development, its measurement could be important in assessing seedling response due to cultural treatment (Fig. 1) and its potential for survival and growth after planting. Stem length of low density seedlings was consistently greater than stem length of high density seedlings with a marked increase occurring under moist conditions (moisture regime A). Little increase in stem length was noted regardless of density and moisture treatments between 0 and 72 kg/ha N. Moisture regime B seedlings exhibited substantial increases in stem length with additional supplies of N.

TABLE 1 Increase in dry weight, root area index, root collar diameter, and height of seedlings at the low seedbed density expressed as a percentage of the increase at the high seedbed density

	Moisture regime			
	A	B	C	MEAN
	75	40	83	68.0
72	134[a]	72	56	90.6
144	116[a]	130	79	93.0
288	114[a]	72	54	80.0
MEAN	111.5	72.3	69.5	84.5
	72	67	82	74
72	66	37	48	50
144	45	66	57	56
288	64	78	55	66
MEAN	62	62	60	61.3
	52	41	41	45
72	64	35	27	42
144	61	43	36	47
288	58	41	25	42
MEAN	58	40	32	43.7
	32	32	27	30.3
72	32	28	24	28.0
144	44	11	10	21.6
288	58	9	0	15.2
MEAN	32.0	20.0	15.2	22.4

[a] Significant interaction ($P<0.05$)

TABLE 2 Coefficient of variation values (percent) of dry weight, root area index, root collar diameter, and height for seedlings for all treatment combinations of irrigation and nitrogen supply at two seedbed densities

	Seedbed density							
	410/m²				215/m²			
N Supply kg/ha	Moisture regime A	B	C	MEAN	Moisture regime A	B	C	MEA
Dry Weight								
0	16.97	23.04	24.41	28.14	28.83	52.62	14.47	31.98
72	15.56	22.68	18.04	25.04	15.12	24.83	45.83	45.26
144	25.71	33.31	18.62	25.88	1.04	11.41	11.57	8.01
288	9.31	15.05	16.64	20.61	19.44	18.52	11.24	23.23
MEAN	21.89	23.75	29.71	25.07	14.65	24.22	21.78	19.59
Root Area Index								
0	38.29	36.04	41.11	35.52	24.22	11.04	26.30	35.29
72	30.79	29.75	14.14	31.23	26.52	31.57	28.91	29.1
144	29.95	21.89	40.51	31.29	15.29	31.13	23.74	27.05
288	46.52	17.26	29.04	17.87	31.70	14.29	37.57	32.52
MEAN	36.39	31.04	36.71	34.00	26.73	15.30	25.27	23.84
Diameter								
0	19.91	24.60	30.14	24.97	18.41	17.24	21.38	19.01
72	18.71	23.87	21.51	25.04	19.20	19.05	22.75	19.1
144	17.29	21.56	30.36	24.97	17.07	16.43	18.51	17.34
288	22.44	20.90	18.84	23.21	16.82	22.21	21.35	22.8
MEAN	19.59	24.98	25.71	24.44	16.38	19.08	21.75	19.
Height								
0	19.56	22.80	21.68	21.14	16.44	20.10	23.80	19.7
72	20.21	21.01	27.06	22.76	21.17	21.12	27.15	21.1
144	17.36	19.21	22.07	19.54	16.26	16.27	18.59	16.2
288	23.52	24.23	26.04	26.26	19.32	23.17	23.90	25.29
MEAN	26.88	30.75	24.21	22.47	17.79	22.03	24.11	21.1

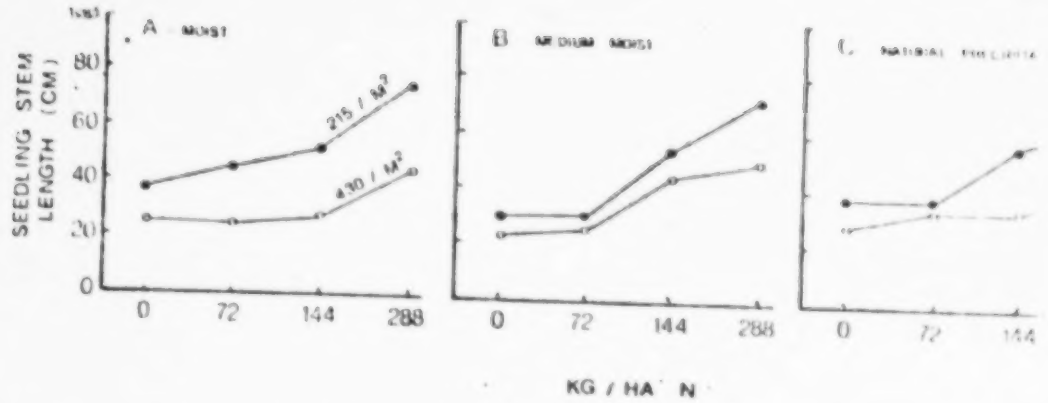

FIG. 1 Mean total stem lengths of 2+0 white spruce subjected to four l of N supply and irrigation control at two seedbed densities.

Variability of Seedling Growth. Seedling uniformity should be an impor objective in nursery soil management and can be affected by the cultura treatments applied to nursery production areas. Seedling variability w examined in terms of each growth parameter through coefficient of varia values for each treatment combination (Table 2). Seedlings grown at th low seedbed density portrayed less *overall* variability compared to seed grown at the high seedbed density, i.e. for dry weight, 19.96 *VS* 25.07; root area index, 29.82 *VS* 34.98; diameter, 19.94 *VS* 23.43; height, 21.5 *VS* 22.47. Considering density levels individually, we find that lower ient of variation values were generally associated with treatments of f irrigation (e.g. moisture regime A) and mid-range N supply (72-144 kg/ha

Discussion

Seedling Development. Results and observations of this study show that seedling growth exhibits an inverse relationship to seedbed density. Th also illustrate that the commonly used indicators of growth respond in a unique way to density, irrigation, and fertilization, as shown in Fig. 1 This information has particular relevance for the nursery manager as it shows how the relative proportions of stock will be altered by the manip tion of density and influenced by moisture and N fertilization. It also emphasizes that one cannot implement cultural practices for the benefit one attribute of the seedling only, instead the entire seedling must be considered.

By today's cull standards for conifer stock, seedling dry weight a stem diameter are important features of stock quality, as is root develo ment. A substantial increase in seedling dry weight can be realized by growing seedlings at reduced seedbed densities. Richards et al (1973) theorized that this may be caused by increased branching. It was shown the present study that branch length increased with a decrease in seedbe density and presumably so did leaf surface area. This effected a greater capacity of the seedlings to photosynthesize and accrete dry weight. Mois and nutrient supplies apparently modified the rate of dry weight accumula

Seedling Variability. Under reduced seedbed densities seedling developm exhibited less variability than that of seedlings grown at high seedbed densities. Furthermore, unrestricting supplies of moisture and nitrogen (and other nutrients) promoted morphological uniformity amongst seedlings

Nursery practices should strive for uniformity through cultural treatments rather than relying solely on hand grading and culling, as unnecessary wast is common in this procedure. Bunting (1973) and others (Shoulders 1961, Muntz 1944) noted that for white spruce the cull percentage increases (based on a stem diameter of 3.6 mm) from 0% at a seedbed density of 162 trees/m^2 to 7% at 323 trees/m^2; extrapolated to 436 trees/m^2 cull percentages may be as high as 40%. Higher cull ratios are common. It is thus hypothesized that large variability amongst seedlings and resulting high cull ratios are the partial products of an imbalance in seedbed management.

Conclusions

In view of the results of this study the following conclusions can be drawn for seedbed management of white spruce seedlings:

1. The regulation of density, apart from affecting total production per unit area, is a practical technique to increase seedling dry weight and root development with only minimal gains in height growth.

2. When grown under unlimiting conditions of moisture and fertility at *acceptably* low seedbed densities, stock uniformity can be enhanced and cull percentages reduced, thereby offering potential savings in stock production costs.

3. Consideration must be given to the resulting physiological quality of stock if culturing techniques are modified to produce stock of different morphological characteristics so that potential field survival and growth are not jeopardized.

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